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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Allocation of Spectrum Below 5 GHz Transferred from Federal Government Use	)	ET Docket No. 94-32

To: The Commission

COMMENTS OF THE RADIO AMATEUR SATELLITE CORPORATION

The Radio Amateur Satellite Corporation (AMSAT) respectfully submits these comments in response to the Commission's Notice of Inquiry, ET Docket No. 94-32, released May 4, 1994.

Background

1. AMSAT, a not-for-profit District of Columbia corporation established in 1969, is the principal membership organization of the amateur-satellite community in North America. Together with our affiliated organizations throughout the world, we have constructed, launched and operated over two dozen satellites to date in the amateur-satellite service, of which the majority are presently in operation. These currently operational spacecraft include high-altitude, Molniya-type orbit transponder satellites capable of sustaining two-way communication over terrestrial paths well in excess of 10,000 miles (AMSAT-OSCAR 10 and AMSAT-OSCAR 13), numerous low-earth-orbit (LEO) digital store-and-forward packet radio satellites, scientific and educational payload satellites, LEO analog transponder satellites, and several spacecraft featuring combinations of these types of payloads.

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2. Additional satellites or satellite hardware for the amateur-satellite service are planned or are presently under construction by AMSAT and its affiliate organizations in Argentina, Australia, Chile, Finland, Germany, Indonesia, Israel, Italy, Japan, Korea, Mexico, the Philippines, Russia, Sweden and the United Kingdom. Many of these groups are associated with universities or have access to government or industry facilities in their countries. Indeed, owing to the worldwide and cooperative nature of amateur radio, the construction of satellites for the amateur-satellite service has emerged as a principal means of technology transfer to developing countries. One not-for-profit organization, Surrey Satellite Technologies Ltd., associated with the University of Surrey in the United Kingdom, has built or aided in the construction of eight such satellites, with more on the way. AMSAT itself is currently working with amateur satellite construction groups in nearly a dozen countries to build the fourth and most advanced in a series of elliptical orbit amateur satellites we call "Phase 3D". The next ten to twenty years is certain to see a further proliferation of this highly beneficial activity, with commensurate demands on frequency spectrum available to the amateur-satellite service.

Disruption of Existing Use of Federal Government Frequencies by Amateur Service Licensees - [Paragraph 9(c) of the Notice of Inquiry]

3. Title VI of the Omnibus Budget Reconciliation Act of 1993 (the "Reconciliation Act") requires that the Secretary of Commerce shall seek to avoid "excessive disruption of existing use of Federal Government frequencies by amateur radio licensees" [47 U.S.C. para. 923(c)]. In addition, at 47 U.S.C. para. 923(c)(3)(C), the Reconciliation Act specifies that the Secretary shall consider, in analyzing the benefits from a particular reallocation, "the extent

to which, in general, commercial users could share the frequency with amateur radio licensees." Finally, the Reconciliation Act lists five possible grounds for the substitution or withdrawal of proposed reallocation frequencies, one of which is if: "the reassignment will disrupt the existing use of a Federal Government band of frequencies by amateur radio licensees" [47 U.S.C. para. 924(b)(2)(E)]. In view of the integral role in this reallocation process which the Reconciliation Act assigns to the Commission (including, for example, joint spectrum planning between the Commission and NTIA [47 U.S.C. para. 922] and sole responsibility for review and analysis of public comments in response to the NTIA's Preliminary Report [47 U.S.C. para. 923(d)]), it is clear that the intent of Congress was to protect the amateur radio community from excessive disruption, and that the responsibility for such protection rests as much on the Commission as on the Secretary of Commerce and the President.

4. As the Commission notes, the NTIA excluded 2400-2402 MHz from the proposed reallocation. These frequencies are of vital importance to spacecraft operations in the amateur-satellite service, for satellites in current use as well as those under construction. However, in the readily foreseeable future, AMSAT anticipates greatly increased demand for amateur satellite operations in that portion of the spectrum, far more than can reasonably be accommodated within a 2 MHz band. It is certainly too restricted to accommodate such wideband techniques as fast-scan television, even if compression techniques are employed. AMSAT hopes to be able to employ such modes on future spacecraft. The 10 MHz wide 1260-1270 MHz uplink-only amateur-satellite service allocation is available for such applications, and a similar bandwidth is needed as a paired downlink near 2400 MHz.

Sharing of the 2400 MHz Band between Amateur Operations and New Non-Federal Services - [Paragraph 9(d) of the Notice of Inquiry]

5. Amateur operation in the 2400 MHz band, and all other amateur and amateur-satellite assignments from 420 MHz to 10 GHz, have been on a secondary basis. This has worked quite well when amateur operators were sharing with Government users, mostly radiolocation devices, many of which were on ships at sea or on foreign soil. However, in cases where amateurs have shared with high-density commercial users, such as in the 902-928 MHz band, a greater number of conflicts have arisen. AMSAT contends that commercial users, who may offer large sums for access to spectrum, are most unlikely to be willing to share their expensive bounty with amateurs. From the amateur standpoint, such sharing will not be successful with high-density commercial users, especially where the amateur application involves the reception of relatively weak amateur satellite downlink signals or very weak signals associated with long-distance terrestrial operation or earth-moon-earth work.

6. Unlike commercial satellite services for which the use of geostationary spacecraft is economically feasible, the amateur-satellite service utilizes satellites in low or highly elliptical orbits, which serve all or most of the globe with one set of uplink and downlink frequencies. For this reason, amateur satellite frequency allocations must be coordinated internationally so that they are available for use on a worldwide basis. Internationally, the ITU allocation in the 2.4 GHz band to the amateur-satellite service is 2400-2450 MHz. Any reallocation of frequencies in the United States from this service to another, or any introduction of additional or substituted sharing partners, would certainly have adverse

effects on the amateur-satellite service worldwide, and would be difficult to coordinate with all the other national administrations.

Level of Usage of the 2.4 GHz Band by the Amateur and Amateur-satellite Services

7. Although current amateur and amateur satellite use of the 2.4 GHz band may be considered light by standards used to judge other parts of the spectrum, the use of this band is expected to increase greatly in the next few years. Like other users of the radio spectrum, amateurs tend to migrate from lower frequencies to higher frequencies as the years pass, suitable equipment becomes available and the state-of-the-art advances. In its Preliminary Report, NTIA appeared to judge current and future amateur use of the spectrum by different standards than it applied to other current and potential users. With that thought in mind, we will outline current and future amateur satellite usage of the 2.4 GHz portion of the spectrum. But first we wish to point out that the amateur satellite community has pioneered the use of the 2300-2450 MHz band for amateur satellites since the early 1970's: AMSAT-OSCAR 7, launched in 1974, carried a beacon on 2304.1 MHz. In addition, UOSAT-OSCAR 9 built at the University of Surrey in the U.K. and launched in 1981, contained beacons on 2401 and 10,470 MHz.

Current Usage

8. Several amateur satellites currently utilize the 2.4 GHz band:

AMSAT-OSCAR 13, launched in 1988, has a downlink on 2400.711-2400.747 MHz with a beacon at 2400.650 MHz. Use of this downlink has seen increasing use, especially over the past year, since the failure of the satellite's 435 MHz transmitter which was paired with an uplink on 1270 MHz.

UOSAT-OSCAR 11, built at the University of Surrey in the U.K. and launched in 1984, carries a beacon on 2401.5 MHz which continues to function.

PACSAT-OSCAR 16 (AO-16), one of four MICROSATs built in the U.S. in the late 1980's and launched in January 1990, contains a beacon on 2401.1 MHz which is presently functional.

DOVE (DO-17), another of the four MICROSATs launched in January 1990, has a beacon on 2401.220 MHz. This has proved invaluable in attempts to rescue this satellite from mission-threatening situations involving interference to the 144 MHz command receiver from the satellite's 145.825 MHz downlink transmitter. Often, the 2.4 GHz downlink has been the only means to confirm the satellite's acceptance of commands.

The French built Arsene amateur satellite includes a 16 kHz wide downlink at 2446.500 MHz., near the center of the 2400-2500 MHz ISM band. Unfortunately, that transmitter failed several months after launch. Before that failure, a number of amateurs around the world reported hearing this downlink. But the relatively small number of amateurs equipped to receive weak signals this high in the band did not permit a definitive assessment of the viability of satellite downlink reception so close to the frequencies occupied by microwave ovens in the short time available.

Near-term Plans

9. The most immediate planned amateur satellite use of the 2.4 GHz band is for Phase 3D. This large amateur satellite is scheduled for launch by the European Space Agency on an Ariane 5 launch vehicle in April 1996. Phase 3D will include a number of uplinks and downlinks in amateur-satellite bands from 21 MHz to 24 GHz. At 2.4 GHz, one of the principal downlinks is planned, along with an experimental uplink. These are to utilize the following specific frequencies:

Downlink	2400.500 - 2400.900 MHz
Uplink	2400.100 - 2400.500 MHz

Consideration is being given to moving this experimental uplink, perhaps to the vicinity of 2410 or 2450 MHz. The latter would enable evaluation of the potential interference, as observed in orbit, of various ISM devices including microwave ovens.

Longer-Term Plans

10. The amateur-satellite service can be expected to make significant use of the 2.4 GHz band, especially for downlinks, over the next ten to twenty years due to overcrowding of the lower frequency bands and the need for wider bandwidths.

11. The intense crowding taking place on the lower VHF and UHF amateur bands necessitates the use of the higher frequencies by amateur satellites. The situation is particularly bad in the 144-146 MHz band, which is the only portion of the VHF spectrum presently allocated to the amateur-satellite service on a primary basis by the ITU. The ready availability of inexpensive equipment intended for the amateur market has resulted in extensive use of this band by non-amateurs for personal and commercial communications in many countries, especially in Asia and the Pacific Rim, despite ITU regulations to the contrary. First-hand observations by radio amateur astronauts flying in the Space Shuttle and radio amateur cosmonauts aboard MIR have confirmed that non-amateur use of the 144-146 MHz amateur band is a significant and growing problem for amateur space communications. Even in the U.S., where non-amateur use is not as much of a problem as it is elsewhere, the 144-146 MHz band is becoming increasingly congested by various types of amateur terrestrial usage. This intense use is making the band increasingly difficult to use, especially for the relatively weak signal satellite downlinks.

12. A similar situation is developing in the 435-438 MHz band allocated on a secondary basis by the ITU to the amateur-satellite service. In many parts of the world, use of this band for satellite uplinks is rendered virtually impossible at times by the presence of high-powered

radar stations such as PAVE PAWS. This has proven especially true with respect to digital applications such as packet radio and earth-to-space command links.

13. Two internal problems facing amateur radio are the proliferation of modes of operation, many inherently wideband in nature, and the increasing number of amateur radio operators since institution of the code-free license. The American Radio Relay League (ARRL) indicates that the number of licensed amateur stations in the U.S. is growing at the rate of over seven percent per year, with most of that growth attributed to the no-code Technician License. Both of these situations will require greater use of the microwave bands in coming years, especially the 2.4 GHz band.

14. A mode of operation, growing in popularity, is fast-scan amateur television. Several manufacturers currently offer low-cost amateur television transmitters for the 420-450 MHz band. As no such commercial amateur television equipment is manufactured for any of the higher amateur bands, this band is receiving the brunt of amateur television operation. Since amateur FM repeaters occupy almost all of the 440 to 450 MHz range, and 420 to 430 MHz is not available everywhere in the U.S., most amateur television operation takes place between 430 and 440 MHz. Many of these commercial amateur TV transmitters, and most home constructed units, transmit signals 8 MHz in width (both sidebands), often causing interference to reception of amateur satellites in the 435 to 438 amateur-satellite band as well as to weak signal work taking place near 432 MHz. This problem is greatly exacerbated in the many other countries of the world where only 430-440 MHz, or parts thereof, is available for amateur operation.

15. As a result of this worsening situation in the VHF and lower UHF bands, groups planning and implementing amateur satellites in the future will have to use the higher frequency allocations. The specific selection of bands must, however, take into consideration the economic status and technical expertise of potential users worldwide, not merely those in the United States or in other highly developed countries.

16. Amateur satellites are completely different from satellites built for other applications. In the case of commercial or government satellites, while the spacecraft is being constructed and prepared for launch, suitable ground station equipment is being developed and deployed. Usually, both of these are funded and directed by the same company or government agency. This assures that the ground equipment will be in place when the space segment comes on line and that the two will be compatible with one another. This is not true with amateur satellites. In this case, the space segment is constructed by a specific amateur group such as AMSAT, or a collection of such groups. In planning the satellite, the constructors attempt to understand the current and future capabilities and needs of individual amateurs throughout the world. This often means that they must compromise in the design of the satellite, frequently choosing lower frequency bands and lower data rates than would be optimal otherwise.

17. With the aforementioned crowding in the 145 and 435 MHz amateur bands, future amateur satellites will depend heavily on the next higher bands, 1.2 and 2.4 GHz. The amateur-satellite service allocation in the 1.2 GHz region, 1260-1270 MHz, is designated for use as uplinks only. Under ITU regulations, the lowest available frequency range for amateur-satellite downlinks above 438 MHz is 2400-2450 MHz. The next amateur-satellite

band, 3400-3410 MHz, is not available worldwide, and therefore is not likely to be used for amateur satellites unless a worldwide allocation can be obtained. The next higher downlink allocation is 5830-5850 MHz. Because of the congestion on the lower bands and the economic and technical considerations on the higher bands, it is the 2400 MHz band which will bear the greatest burden of supporting the growth of the amateur-satellite service over the next ten to twenty years. But it is difficult to see how it can do so if only 2 MHz of spectrum is available.

18. Currently, the amateur-satellite service allocation in the 2.4 GHz region is 2400-2450 MHz, both in the FCC and international tables. It would appear that to efficiently use the 10 MHz wide 1.2 GHz uplink assignment, a corresponding 10 MHz wide assignment at 2.4 GHz would be reasonable and necessary.

19. While there is a commonality of interest between amateur operators who use weak-signal modes such as earth-moon-earth or long-haul terrestrial means of propagation, and those amateurs participating in satellite operation, the use of common or nearby frequencies by these two groups often leads in practice to mutually destructive interference. Furthermore, relatively narrow allocations, available on a primary basis, form the best approach of accommodating and encouraging both of these potentially valuable activities. Currently, most amateur weak-signal work in the 2.4 GHz band is conducted in the vicinity of 2304 MHz, although in some countries other frequencies are employed due to non-availability of the 2300-2310 MHz segment to amateurs. Like satellite operation, although to a lesser extent, weak-signal operation is best accomplished on common worldwide primary allocations. This is especially true of earth-moon-earth operation.

Needless to say, successful earth-moon-earth operation requires the utmost in performance of all elements of the system from high-power amplifiers, receive pre-amplifiers and antennas. Unfortunately, wide frequency separation between transmit and receive frequencies, necessitated by varying allocations, often leads to less than optimum equipment performance, especially in the case of antennas.

Advanced Technology Planning and Experimentation

20. An important purpose of the Reconciliation Act is to facilitate the development of "new and innovative technologies" for the benefit of the public [P.L. 103-66, Sec. 6002 et seq.] The amateur-satellite service is in the forefront of just such technologies, illustrated in the next five paragraphs.

21. New satellite and ground-based telecommunications systems being authorized by the FCC have benefited from the advances made in experiments developed for use in the amateur-satellite service. To cite one significant example, the LEO satellite systems now being authorized by the FCC use packet radio hardware and software technologies originally developed by the amateur radio community for use in the amateur-satellite service, particularly for the AMSAT MICROSATs and the University of Surrey's UOSATs.

22. As an extension of this spinoff concept, the amateur-satellite community is evolving standards for high-speed digital data and digital video transmission using compression technologies that are ideally suited for small satellite applications. In order to test and implement this type of technology, frequency allocations with adequate bandwidth are essential. The 2.4 GHz frequency band is the best suited frequency band for the downlink for this type of experimental digital communications. The communications transponders

used would pair uplinks at 1260-1270 MHz with downlinks in the 2400-2410 MHz frequency band.

23. Amateur satellite groups are also doing pioneering work in the development of high-efficiency, high-power amplifiers for this portion of the radio spectrum. Transponders employing such linear amplifiers exhibiting DC to RF efficiencies as high as 40 percent have already been developed by the amateur community for various frequency bands, including 2.4 GHz. The Phase 3D spacecraft will carry a 2.4 GHz solid-state solid-state transmitter employing a linear amplifier capable of in excess of 100 watts of RF power output. The spacecraft's three-axis stabilization will permit the use of a high-gain antenna producing an effective radiated power of over 10 kilowatts in the direction of the earth.

24. These technologies under development by amateur groups, when taken together and with an adequately wide 2.4 GHz amateur-satellite allocation, will provide powerful demonstrations of low-cost digital video and data transmission techniques. These technical approaches differ from direct broadcast technologies because they are bi-directional and will involve different multiple amateur uplink stations. Both time-division and code-division multiple access techniques are under consideration.

25. In addition to experimentation with digital video and high-speed packet data links, several amateur experimenters have expressed an interest in investigating low-cost spread spectrum techniques. Spread spectrum communications experiments are important because they may lead to feasible methods of spectrum sharing by various commercial satellite and terrestrial services, applications currently under consideration by the Commission.

Frequency-Sharing and Interference Considerations

26. Interference experienced in the amateur-satellite service as a result of high-powered devices such as radars and interference arising from amateur and non-amateur use of the 144-146 and 435-438 MHz bands have already been cited. Some interference from radars is also present in the 1260-1270 MHz uplink band. The 2.4 GHz band presents a unique challenge in that ISM devices, principally microwave ovens, are present. Microwave ovens are particularly troublesome for amateur operators because they are found in most homes, and most amateurs operate in residential areas. For this reason, amateur and amateur-satellite operation should be afforded a part of the band as far away from that occupied by ISM devices as possible. The Commission is reminded that, following a study done for the Voice of America, the U.S. sought an allocation at WARC-92 for broadcast-satellite service (sound) from 2310-2360 MHz - as far away, in that band, from the 2450 MHz ISM center frequency as possible. AMSAT wonders how close to 2450 MHz the majority of microwave ovens remain. We would welcome any data the Commission or others may have on the subject. It has also been shown that experimental weak-signal amateur operation, such as earth-moon-earth and long-haul tropospheric work, must have as clear a frequency as possible. This potentially valuable type of work is currently concentrated at 2300-2310 MHz, specifically near 2304 MHz.

27. The amateur-satellite service presently utilizes and expects to significantly expand its use of the 2.4 GHz band. As mentioned before, this band is a prime developing area of the spectrum for amateur communication experiments and applications. Due primarily to the extremely high cost of geostationary satellites, no amateur spacecraft of that type has yet

been launched. Therefore, amateur satellites are in lower or elliptical orbits that cover virtually the entire earth, albeit not all regions simultaneously. Consequently, the frequencies used by amateur satellites must be available worldwide. Thus, unlike terrestrial applications or those involving geostationary satellites, allocations of spectrum to the amateur-satellite service must be made consistently throughout the world, rather than on a national or regional basis. Therefore, any decisions with regard to allocations for the amateur-satellite service made in the United States must be coordinated with other governments. Otherwise, the results are likely to prove useless for the purposes for which they are intended. A case in point is the 3400-3410 MHz amateur-satellite allocation currently provided for in the ITU Table of Allocations. This segment is stated as being available, but in Regions 2 and 3 only. Since it is not available in Region 1, it has not yet been employed for amateur satellite use. It is for this reason that this is the only band between 21 MHz and 24 GHz not being considered for inclusion in the Phase 3D spacecraft now under construction.

28. The current ITU amateur-satellite service allocation in the 2.4 GHz band consists of 2400-2450 MHz. While we are very concerned that, particularly in the metropolitan and suburban areas where most licensed amateurs live, interference levels from microwave ovens and ISM devices would be severe enough to render the frequencies near 2450 MHz very difficult, if not impossible to use for satellite downlinks, it may be possible to accommodate some uplinks in that end of the band.

29. In addition to satellite and weak-signal work, many amateur experimenters are interested in relatively short-range terrestrial activities such as amateur television and high-speed data

transmission. Some of that type of work is already being done in the 2.4 GHz band. These kinds of activities generally require relatively large bandwidths and higher received signal levels than do satellite, long-haul tropospheric or earth-moon-earth work. These wider-band, shorter-range activities are certain to increase in number over the next 10 to 20 years, and will need to be accommodated.

Recommendations

30. In view of these considerations and the anticipated near-term future needs of the amateur and amateur-satellite services, AMSAT urges the Commission to take the following actions:

a. Establish a 10 MHz wide portion of the existing amateur and amateur-satellite band from 2400-2410 MHz on a primary basis, with no sharing partners except for the existing ISM assignment.

b. Retain access, for the amateur service, to 2390-2400 MHz and, for the amateur and amateur-satellite services, to 2410-2450 MHz, both on a secondary basis shared with what are, according to the Commission's determination and the considerations outlined in Paragraphs 26-29 above, the most compatible sharing partner(s).

c. Provide at least 1 to 2 MHz of space, on a primary basis, for the amateur service in order to accommodate weak-signal terrestrial and earth-moon-earth experimentation. This small window should be as far from 2450 MHz as possible, preferably near the presently used 2304 MHz amateur frequency.

Conclusion

31. AMSAT believes that by implementing the foregoing recommendations, the Commission will facilitate the continuing growth and development of the amateur and amateur-satellite

services and provide the amateur community with the renewed confidence (including assurance to prospective manufacturers of equipment and components) needed to go forward with new innovative techniques and contributions to the communications industry. The amateur radio community represents a valuable national resource which has proved its value in time of emergency and as a means of bringing the younger generation into technical professions. Without continued access to adequate frequencies throughout the spectrum, the public interest served by the amateur and amateur-satellite services will be adversely affected.

RESPECTFULLY SUBMITTED,

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